

HAZARDOUS WASTE COMBUSTION

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OVERVIEW

Approximately 200 TSDFs use **combustion**, the controlled burning of substances in an enclosed area, as a means of treating and disposing of hazardous waste.

As a hazardous waste management practice, combustion has several unique attributes. First, if properly conducted, it permanently destroys toxic organic compounds contained in hazardous waste by breaking their chemical bonds and reverting them to their constituent elements, thereby reducing or removing their toxicity. Second, combustion reduces the volume of hazardous waste to be disposed of on land by converting solids and liquids to ash. Land disposal of ash, as opposed to disposal of untreated hazardous waste, is in many instances both safer and more efficient.

Combustion is an intricate treatment process. During burning, organic wastes are converted from solids and liquids into gases. These gases pass

through the flame, are heated further, and eventually become so hot that their organic compounds break down into the constituent atoms. These atoms combine with oxygen and form stable gases that are released to the atmosphere after passing through air pollution control devices.

The stable gases produced by combustion of organics are primarily carbon dioxide and water vapor. Depending on waste composition, however, small quantities of carbon monoxide, nitrogen oxides, hydrogen chloride, and other gases may form. These gases have the potential to cause harm to human health and the environment. The regulation of these emissions is the primary focus of the RCRA combustion unit standards.

The management or disposal of metals and ash, other by-products of the combustion process, also causes concern. Ash is an inert solid material composed primarily of carbon, salts, and metals. During combustion, most ash collects at the bottom of the combustion chamber (**bottom ash**). When this ash is removed from the combustion chamber, it may be considered hazardous waste via the derived-from rule or because it exhibits a characteristic. Small particles of ash (particulate matter that may also have metals attached), however, may be carried up the stack with the gases (**fly ash**). These particles and associated metals are also regulated by the combustion regulations, as they may carry hazardous constituents out of the unit and into the atmosphere. Since combustion will not destroy inorganic compounds present in hazardous waste, such as metals, it is possible that such compounds may also end up in bottom ash and fly ash at

harmful concentrations. Ash residue is subject to applicable RCRA standards and may need to be treated for metals or other inorganic constituents prior to land disposal.

In the early years of RCRA, EPA intended for facilities to combust as much hazardous waste as possible and landfill the resultant ash. This process destroyed the majority of the waste, thus reducing the volume requiring disposal. However, it was determined that incomplete or improperly conducted combustion had the potential to present a major public health risk, and therefore, became the topic of much public outcry. This public concern, coupled with EPA's advancements in assessing potential risks arising from combustion, caused a shift in EPA's strategy on combustion. This shift in thinking resulted in the increasing stringency of combustion requirements over time.

WHAT ARE THE REGULATED UNITS?

Hazardous wastes are combusted for various purposes. The purpose of combustion is directly related to the type of unit used. There are two classes of combustion units, those that burn waste for destruction and those that burn waste for energy recovery or recover materials from the hazardous waste.

■ Incinerators

The first class of combustion units are hazardous waste incinerators. Incineration is the combustion of hazardous waste primarily for destruction (i.e., disposal). Incineration is a method of thermal destruction of primarily organic hazardous waste using controlled flame combustion. This process can reduce large volumes of waste materials to ash and lessen toxic gaseous emissions. An **incinerator** is an enclosed device that uses controlled flame combustion and does not meet the more specific criteria for classification as a boiler, industrial furnace, sludge dryer (a unit that dehydrates hazardous sludge), or carbon regeneration unit (a unit that regenerates spent activated carbon). Incinerators also include infrared incinerators (a unit that uses electric heat followed by a controlled flame

afterburner) and plasma arc incinerators (a unit that uses electrical discharge followed by a controlled flame afterburner).

■ Boilers and Industrial Furnaces

The second class of combustion units are boilers and industrial furnaces (BIFs). Boilers are used to recover energy from hazardous waste, while industrial furnaces are used to recover energy and/or material values from the hazardous waste.

EPA defines **boilers** as enclosed devices that use controlled flame combustion to recover and export energy in the form of steam, heated fluid, or heated gases. A boiler is comprised of two main parts, the combustion chamber used to heat the hazardous waste and the tubes or pipes that hold the fluid used to produce energy. The regulatory definition of boiler requires that these two parts be in close proximity to one another to ensure the effectiveness of the unit's energy recovery system and to maintain a high thermal energy recovery efficiency. In addition, the unit must export or use the majority of the recovered energy for a beneficial purpose.

Industrial furnaces are enclosed units that are integral parts of a manufacturing process and use thermal treatment to recover materials or energy from hazardous waste. These units may use hazardous waste as a fuel to heat raw materials to make a commodity (e.g., a cement kiln making cement) or the unit may recover materials from the actual hazardous waste (e.g., a lead smelter recovering lead values). The following 12 devices meet the definition of an industrial furnace:

- **Cement kiln**
- Aggregate kiln
- Coke oven
- Smelting, melting, and refining furnace
- Methane reforming furnace
- Pulping liquor recovery furnace
- Lime kiln
- Phosphate kiln
- Blast furnace
- Titanium dioxide chloride process oxidation

reactor

- Halogen acid furnace (e.g., hydrochloric acid production furnace)
- Combustion device used in the recovery of sulfur values from spent sulfuric acid.

After notice and comment, EPA may add other devices to this list of industrial furnaces upon consideration of factors related to the design and use of the unit.

Not all units that meet the definition of boiler or industrial furnace are subject to the 40 CFR Part 266, Subpart H, boiler and industrial furnace standards. Each individual unit must first be evaluated against a number of exemptions from the BIF requirements. For a variety of reasons (e.g., to avoid duplicative regulation), EPA exempted the following units from the BIF regulations:

- Units burning used oil for energy recovery
- Units burning gas recovered from hazardous or solid waste landfills for energy recovery
- Units burning hazardous wastes that are exempt from RCRA regulation, such as household hazardous wastes
- Units burning hazardous waste produced by conditionally exempt small quantity generators (CESQGs)
- Coke ovens burning only K087 decanter tank tar sludge from coking operations
- Certain units engaged in precious metals recovery
- Certain smelting, melting, and refining furnaces processing hazardous waste solely for metals recovery
- Certain other industrial metal recovery furnaces.

REGULATORY REQUIREMENTS

Emissions from hazardous waste combustors are regulated under two statutory authorities—RCRA and the Clean Air Act (CAA). Applicable RCRA regulations include 40 CFR Part 264, Subpart O, and

Part 265, Subpart O, for incinerators and 40 CFR Part 266, Subpart H, for BIFs. RCRA permitting requirements for these units are provided in 40 CFR Part 270. These units are also subject to the general TSDF facility standards under RCRA. Certain combustion units that burn hazardous waste are also subject to emission standards under the CAA, including incinerators, cement kilns, **lightweight aggregate kilns**, industrial boilers, and hydrochloric acid production furnaces. The **maximum achievable control technology (MACT)** standards set emission limitations for dioxins and furans, metals, particulate matter, hydrogen chloride and chlorine, hydrocarbons/carbon monoxide, and **destruction and removal efficiency (DRE)** for organics. Once a facility has demonstrated compliance with the MACT standards by conducting its comprehensive performance test and submitting its Notification of Compliance (NOC), it is no longer subject to the RCRA emission requirements with few exceptions. RCRA permitted facilities, however, must continue to comply with their permitted emissions requirements until they obtain modifications to remove any duplicative emissions conditions from their RCRA permits. Also, RCRA permits will continue to be required for all other aspects of the combustion unit and the facility that are governed by RCRA (e.g., corrective action, general facility standards, other combustion-specific concerns such as materials handling, risk-based emission limits and operating requirements, and other hazardous waste management units.) The combustion standards under RCRA, as well as the MACT standards under the CAA, are discussed below.

In September 1999, EPA issued a joint Clean Air Act (CAA)/RCRA rule that upgraded the emission standards for Phase I hazardous waste combustors (i.e., incinerators, cement kilns, and lightweight aggregate kilns), based on the MACT approach commonly employed under the CAA. This process develops technology-based, emission limits for individual hazardous air pollutants. Much like the BDAT concept for land disposal restrictions (LDR) (as discussed in Chapter III, Land Disposal Restrictions), the MACT emission standards are based on the performance of a technology. Research is performed that determines the specific pollutants that need to be treated. The best corresponding

technology is then used to treat those pollutants.

Consistent with EPA's trend of gradually increasing the stringency of standards over time, this joint rule promulgated more stringent emissions standards for dioxins, furans, mercury, cadmium, lead, particulate matter, hydrogen chloride, chlorine gas, hydrocarbons, carbon monoxide, and several low-volatile metals. After the promulgation of this rule, a number of parties representing the interests of both industrial sources and the environmental community, requested judicial review of this rule.

In July 2001, the United States Court of Appeals for the District of Columbia Circuit vacated the challenged portions of the rule. When it made its decision, the Court invited any of the parties to request, either that the current standards remain intact, or that EPA be allowed time to publish interim standards. Acting on this initiative, EPA and the other parties jointly asked the Court for additional time to develop interim standards, and the Court granted this request. On February 13, 2002, EPA published these interim standards which temporarily replace the vacated standards. Since the development of the interim standards, litigation has prevented the promulgation of the final standards. A ruling by the DC court on Brick MACT has prevented the final rule even further from being promulgated.

■ Combustion Standards under RCRA

Emissions from combustion units may comprise a variety of hazardous pollutants. To minimize potential harmful effects of these pollutants, EPA developed performance standards to regulate four pollutant categories: organics, hydrogen chloride and chlorine gas, particulate matter, and metals. Boilers and most industrial furnaces, hereafter referred to as RCRA combustion units, have performance standards that they must meet. For each category or type of emission, the regulations establish compliance methods and alternatives.

Organics

Because the primary purpose of a combustion unit is to destroy the organic components found in hazardous waste, it is essential to verify that the unit

is efficiently destroying organics in the waste. This is determined based on the unit's organic destruction and removal efficiency (DRE) as demonstrated in a trial burn. Since it would be nearly impossible to determine the DRE results for every organic constituent in the waste, certain **principal organic hazardous constituents (POHCs)** are selected for this demonstration. These POHCs are selected for each facility based on their high concentration in the wastestream and their greater difficulty to burn. If the unit achieves the required DRE for the POHCs, then it is presumed that it will achieve the same (or better) DRE for all other easier-to-burn organics in the wastestream. At least one POHC will be selected from each wastestream that the facility manages. The facility designates the selected POHCs in their permit application (the permitting process for combustion units is fully discussed in Chapter III, Permitting of Treatment, Storage, and Disposal Facilities).

The combustion unit must demonstrate a DRE of 99.99 percent for each POHC in the hazardous wastestream. This means that for every 10,000 molecules of the POHC entering the unit, only one molecule can be released to the atmosphere. In addition, due to an increased threat to human health and the environment posed by certain dioxin-containing wastes (F020, F021, F022, F023, F026, and F027), the required DRE for POHCs in these units has been established at 99.9999 percent, or one released molecule for every one million burned. These DRE standards must be met by both incinerators and BIFs.

Hydrogen Chloride and Chlorine Gas

Hydrogen chloride and chlorine gases form when chlorinated organic compounds in hazardous wastes are burned. If uncontrolled, this chlorine can become a human health risk and is a large component in the formation of acid rain. EPA has developed different requirements to control the emissions of chlorine from the different classes of combustion units.

Boilers and most industrial furnaces must follow a tiered system for the regulation of both hydrogen chloride and chlorine gas. The owner and operator determines the allowable feed or emission rate of

total chlorine by selecting one of three approaches, called tiers. Each tier differs in the amount of monitoring, and in some cases, air dispersion modeling (i.e., modeling the air pathways through which pollutants may travel), that the owner and operator is required to conduct.

Each facility can select any of the three tiers. Factors that a facility may consider in selecting a tier include the physical characteristics of the facility and surrounding terrain, the anticipated waste compositions and feed rates, and the level of resources available for conducting the analysis. The main distinction between the tiers is the point of compliance. This is the point at which the owner and operator must ensure that chlorine concentrations will be below EPA's acceptable exposure levels. The owner and operator must determine if the cost of conducting monitoring and modeling is worth the benefit of possibly combusting waste with a higher concentration of chlorine.

Particulate Matter

The third combustion unit performance standard is for **particulate matter**. Particulate matter consists of small dust-like particles emitted from combustion units. The particles themselves are not normally toxic, but may become caught in the lungs (causing respiratory damage) if inhaled, or may enter into the environment where they can cause either ecological damage or, via food chain intake, can reenter the human health exposure pathway. In addition, particulate matter may provide a point of attachment for toxic metals and organic compounds. To minimize these adverse conditions, RCRA combustion units may not emit more than 180 milligrams per dry standard cubic meter (dscm) of particulate matter.

Metals

The final performance standard is for toxic metals. For RCRA combustion units, both carcinogenic and noncarcinogenic metals are regulated under the same type of tiered system as chlorine. The facility determines an appropriate tier for each regulated metal and assures that the facility meets these feed rate and emission standards. A different tier may be selected for each metal pollutant.

Additional Performance Standards

EPA may require owners and operators of hazardous waste combustion units, including those regulated by the CAA MACT standards, to comply with additional performance standards by virtue of the omnibus authority. This authority allows EPA to incorporate additional terms and conditions into a facility's permit as necessary to protect human health and the environment.

EPA recommends that site-specific risk assessments, incorporating direct and indirect exposures, be considered on a case-by-case basis during the combustion unit's permitting process. These risk assessments may be used to evaluate the unit's impact on the surrounding environment. If a site-specific risk assessment shows that additional protection should be afforded to the surrounding environment, EPA will include the necessary permit conditions and limitations in the permit pursuant to the omnibus authority (Omnibus permitting authority is fully discussed in Chapter III, Permitting of Treatment, Storage, and Disposal Facilities).

Operating Requirements

The goal of setting operating requirements for hazardous waste combustion units is to ensure that the unit will operate in a way that meets the performance standards for organics, hydrogen chloride and chlorine gas, particulate matter, and metal pollutants. The unit's permit will specify the operating conditions that have been shown to meet the performance standards for organics, chlorine gas, particulate matter, and metals (permit requirements for combustion units are fully discussed in Chapter III, Permitting of Treatment, Storage, and Disposal Facilities).

A RCRA permit for a hazardous waste combustion unit sets operating requirements that specify allowable ranges for, and requires continuous monitoring of, certain critical parameters that will ensure compliance with the performance standards. Operation within these parameters ensures that combustion is performed in the most protective manner and the performance standards are achieved. These parameters, or operating requirements, may include:

- Maximum waste feed rates
- Control of the firing system
- Allowable ranges for temperature
- Limits on variations of system design and operating procedures
- Gas flow rate.

■ MACT Standards under CAA

Section 112 of the CAA establishes a regulatory process to address emissions of hazardous air pollutants (HAP) from stationary sources, including hazardous waste combustors. Section 112(d) of the CAA requires EPA to promulgate national emission standards for hazardous air pollutants (NESHAP) for hazardous waste combustors. These technology-based NESHAP standards must reflect the maximum reductions of HAP achievable and are commonly referred to as maximum achievable control technology (MACT) standards.

EPA issued the NESHAP for new and existing hazardous waste combustors on October 12, 2005. This final rule established standards for several HAP or HAP surrogates, including chlorinated dioxin and furans, other toxic organic compounds, toxic metals for three different volatility groups (volatile – mercury; semivolatile metals – lead and cadmium; and low volatile metals – arsenic, beryllium and chromium), hydrogen chloride and chlorine, and particulate matter. The emission standards are codified in 40 CFR part 63, Subpart EEE.

In March 2007, a federal court issued an opinion vacating and remanding the CAA section 112(d) MACT standards for the Brick and Structural Clay Ceramics source categories (these categories are a separate source category than hazardous waste combustors). After considering the implications of this court decision, EPA requested a voluntary remand of the MACT standards for hazardous waste combustors. A federal court granted EPA's request in August 2009. As a result of the remand, EPA is required to conduct rulemaking to revise all the MACT emission standards for hazardous waste combustors promulgated in the 2005 rule.

The compliance framework for these MACT combustion units is similar to that used to comply with the RCRA emission standards. Sources are required to demonstrate compliance with emission standards via a comprehensive performance test and establish operating limits to ensure compliance on a daily basis. Generally speaking, sources can use any combination of control technologies to achieve the emission standards (e.g., back-end air pollution controls or front-end pollutant feed controls).

Organics

To control the emission of organics, these units must comply with similar DRE requirements to the other hazardous waste combustion units. Owners or operators of MACT combustion units must select POHCs and demonstrate a DRE of 99.99 percent for each POHC in the hazardous wastestream. Sources that burn hazardous waste F020-F023 or F026-F027 have a required DRE of 99.9999 percent for each POHC designated. Additionally, for dioxins and furans, EPA promulgated more stringent standards under MACT. For example, under the final standards MACT incinerators and cement kilns that burn waste with dioxins and furans, must not exceed an emission limitation of either 0.2 nanograms of toxicity equivalence per dry standard cubic meter (**TEQ/dscm**) or 0.4 nanograms TEQ/dscm at the inlet to the dry particulate matter control device. This unit of measure is based on a method for assessing risks associated with exposures to dioxins and furans.

Hydrogen Chloride and Chlorine Gas

Rather than a tiered system to control hydrogen chloride and chlorine gas emissions, MACT combustion units must meet numerical emission limits for total chlorine. Owners and operators of these units must ensure that the total chlorine emission does not exceed specific limits, expressed in ppmv (parts per million by volume). For example, the current allowable limit of total chlorine for a new incinerator is 21 ppmv. The owner or operator may choose to achieve this level by controlling the amount of chlorine entering the incinerator. By achieving the regulatory emission limit of chlorine, both hydrogen chloride and chlorine gas emissions will be reduced.

Particulate Matter

EPA developed more stringent standards for particulate matter in order to control certain metals. This surrogate is used because particulate matter may provide a point of attachment for toxic metals that can escape into the atmosphere from a combustion unit. For instance, a new LWAK cannot exceed an emission limit of 57 mg/dscm of particulate matter.

Metals

Hazardous waste combustors do not follow a tiered approach to regulate the release of toxic metals into the atmosphere. The MACT rule finalized numerical emission standards for three categories of metals: mercury, low-volatile metals (arsenic, beryllium, and chromium), and semi-volatile metals (lead and cadmium). Units must meet emission standards for the amount of metals emitted. Currently, a new incinerator must meet an emission limit of 8.1 ug/dscm for mercury, 23 ug/dscm for the low-volatile metals, and 10 ug/dscm for the semi-volatile metals.

Operating Requirements

Owners or operators of MACT units must ensure that the MACT emission standards are not exceeded. To do this, the unit must operate under parameters that are demonstrated in a **comprehensive performance test (CPT)**. The unit's operating parameters, such as temperature, pressure, and waste feed are then set based on the result of the comprehensive performance test and documented in a notification of compliance. **Continuous monitoring systems (CMS)** are used to monitor the operating parameters.

The facility may also request to use an advanced type of monitoring known as **continuous emissions monitoring systems (CEMS)**. CEMS directly measure the pollutants that are exiting the combustion unit stack at all times. If a facility is approved to use a CEMS, they do not need to comply with the operating parameter that would otherwise apply.

ADDITIONAL REQUIREMENTS

Because hazardous waste combustion units are a type of TSDF, they are subject to the general TSDF standards (as discussed in Chapter III, Regulations Governing Treatment, Storage, and Disposal Facilities) in addition to combustion unit performance standards and operating requirements. Combustion units are also subject to specific waste analysis, inspection and monitoring, and residue management requirements.

While combusting hazardous waste, the combustion process and equipment must be monitored and inspected to avoid potential accidents or incomplete combustion. The monitoring and inspection requirements for incinerators, cement kilns, and LWAKs are detailed in the CAA regulations, while the requirements for BIFs are determined on a site-specific basis. Possible inspection and monitoring requirements include:

- Monitoring the combustion temperature, and hazardous waste feed rate
- Sampling and analyzing the waste and exhaust emissions to verify that the operating requirements established in the permit achieve the performance standards
- Conducting visual inspections of the combustion unit and its associated equipment
- Testing the emergency waste feed cut-off system and associated alarms
- Placing monitoring and inspection data in the operating log.

Residues from the combustion of hazardous waste are also potentially subject to RCRA regulation. If a combustion unit burns a listed hazardous waste, the ash could also be considered a listed waste via the derived-from rule. The owner and operator must also determine whether this ash exhibits any hazardous waste characteristics. The same is true if a unit burns waste that only exhibits a characteristic. Ash that exhibits a characteristic must be managed as a hazardous waste.

SUMMARY

Combustion, the controlled burning of hazardous substances in an enclosed area, has the potential to adversely affect human health and the environment, and it is therefore subject to strict regulation. As a result, the burning of hazardous waste in incinerators and BIFs is regulated through stack emission limitations and unit operating requirements.

Combustion standards are comprised of two types of regulations: (1) standards under RCRA; and (2) MACT standards under the CAA.

RCRA combustion units must meet performance standards, including a demonstration of the unit's DRE for certain POHCs, and meet emission standards for hydrogen chloride, chlorine gas, metals, and particulate matter. Operating requirements are intended to ensure that the combustion unit will operate in a way that meets the performance standards for these pollutants. Operating conditions may include:

- Maximum waste feed rate
- Control of the firing system
- Allowable ranges for temperature

- Limits on variations of system design and operating procedures
- Gas flow rate.

The MACT standards under the CAA currently regulate several types of combustor units that burn hazardous waste: incinerators, cement kilns, lightweight aggregate kilns, boilers, and hydrochloric acid production furnaces. MACT combustion units must comply with strict emission limitations for dioxins, furans, metals, particulate matter, DRE, and total chlorine. To achieve the limits, the facility owner or operator may use a single or multiple pollution control technologies for the combustion unit. The facility also uses a CMS to monitor operating parameters such as temperature, pressure, waste feed, or CEMS to monitor the pollutants exiting the unit.

ADDITIONAL RESOURCES

A complete overview of the MACT standards and additional information about hazardous waste combustion can be found at www.epa.gov/epawaste/hazard/tsd/td/combustion.htm.